Legacy Site Improvements:
Vegetation Management Framework
(February 2007 Draft)

Introduction

The U.S. Department of Energy (DOE) Office of Legacy Management instituted strategies to "provide continuous improvement in the effectiveness of long-term surveillance and maintenance (LTS&M)" and to "use science and technology to improve sustainability and ensure protection" (DOE 2004). DOE goals include employing "sound…science-based solutions for LTS&M." DOE uses two indicators to measure the success of efforts to improve LTS&M of sites and the sustainability of remedies (DOE 2004):

- Reduction in the cost of operating, monitoring, and maintaining remedies,
- Reduction in risk to human health and the environment.

The Vegetation Management Focus Group is applying this strategy to identify and implement more cost-effective and sustainable ways to manage vegetation at DOE's legacy sites. The group's objective is to integrate and improve management of vegetation with respect to (1) current and long-term remedy performance (e.g., groundwater protection, radon attenuation, biointrusion control) and (2) current and future land use (e.g., weed control, wildlife habitat, livestock grazing). Only those alternative approaches that promise to reduce (or avoid increases in) long-term costs or risks will be implemented.

Assumptions:

- Legacy sites are disturbed, dynamic ecosystems.
- Plant communities at legacy sites will inevitably change in response to climate variability and shifts, soil water and nutrient cycling and availability, soil development processes, propagule accessibility, species interactions (e.g., herbivory, mutualism, and competition), fluctuations in soil microbe populations, and disturbances such as fire.
- Because establishment and changes in plant communities at legacy sites can influence the performance of remedies (e.g., disposal cell covers) and land use goals and requirements (e.g., control of noxious weeds), active vegetation management is often a necessary component of an effective LTS&M program.
- Integrating vegetation management activities at legacy sites and employing principles and practices of applied ecology could improve sustainability of remedies, help ensure long-term protection of human health and the environment, improve land use, and reduce LTS&M costs.

Vegetation Management Framework

The Vegetation Management Focus Group is developing a Vegetation Management Framework that consists of two components: a decision tree and a summary matrix (or table) of information needs. The draft decision tree (see "Decision Tree" file) illustrates the phases and steps of the framework for identifying, evaluating, and implementing improvements in vegetation management practices. Matrices of information needed to step through the decision tree will be developed for each phase of the framework. Matrices will consist of tables with site names in the first column and information categories in subsequent columns as illustrated below.

Site Name	**Groundwater Protection**	**Radon Attenuation**	***Category 3***	***Category 4***	***etc.***
Ambrosia Lake, NM	*	*	*	*	*
Burrell, PA	*	*	*	*	*
Canonsburg, PA	*	*	*	*	*
Durango, CO	*	*	*	*	*
etc.	*	*	*	*	*
etc.	*	*	*	*	*

* Information compiled for a site.

Brief descriptions of the phases and steps of the decision tree follow. In the decision tree diagram, four phases of the framework are shown on the left side, and corresponding dashed lines indicate separations between phases. Process steps and decision points, shown as boxes and diamonds, respectively, are numbered sequentially. The framework is an iterative process of inputting existing information and acquiring additional information needed to propose, test, and implement improved vegetation management practices.

<u>Phase I: Site Screening and Prioritization</u>

DOE manages many different legacy sites that vary with respect to human health and environmental protection requirements, types of remedies, land management requirements, and LTS&M practices. The role vegetation plays in the performance of remedies and the management of surrounding landscapes also varies from site to site. This first phase of the framework is an initial screening to select a subset of sites where vegetation likely plays a significant role in remedy performance and land management—sites where plants could matter.

1a. *Review Remedy Performance Requirements and Risks.* This first step will identify applicable regulations, orders, and guidelines that form the basis for cleanup standards, remedy performance standards, and risk management goals. For example, standards and guidelines for UMTRA sites address groundwater protection, radon attenuation, disposal cell designs, and remedy longevity.

1b. *Review Land Use Goals and Regulatory Requirements.* In parallel with Step 1a, this step will identify land use goals, regulatory requirements, and local restrictions that are the basis for current land management practices. For example, at all sites, management of noxious weed populations is regulated under state and county laws. At some sites, land use restrictions or institutional controls may exist as part of risk management. At other sites, land use goals may include management practices that enhance the ecological value of the landscape, such as improving and sustaining wildlife habitat.

2a. *Understand Compliance Strategies and Remedy Designs.* This step will first review how the remedy or compliance strategy was planned, designed, and implemented (how it is supposed to work). Second, existing monitoring data and any ancillary information will be evaluated to ascertain, if possible, whether the remedy or strategy is performing as planned.

(Is the remedy working as designed to satisfy performance requirements and manage risks?) For example, existing information would be reviewed to understand whether a disposal cell is functioning as predicted with respect to groundwater protection, radon attenuation, erosion control, or biointrusion.

2b. *Understand Current Land Management Practices and Restrictions.* As in Step 2a, existing information will be reviewed to judge whether current LTS&M practices satisfy land use goals and regulatory requirements. For example, does an existing herbicide spray program or biological control program satisfy noxious weed control requirements? Do measures of plant community composition, diversity, abundance, and distribution show whether existing vegetation satisfies wildlife habitat or grazing management goals? This review must engage local stakeholders and take into account public perceptions.

3a. *Could Ecological Processes Influence Remedy Performance and Risk?* The purpose of this step is to segregate sites with respect to the role plant ecology may play in the functioning and performance of remedies and in the occurrence and management of risk. The influence of vegetation could be either beneficial or deleterious. Both planned and unanticipated ecological responses should be considered. The screening process should, if possible, involve an objective ranking of sites based on well-defined selection criteria. However, during this early screening phase, decisions may amount to no more than an educated guess based on professional experience and existing evidence.

3b. *Is Active Vegetation Management Required to Achieve Land Use Goals?* In parallel with Step 3a, this step will segregate sites with respect to the role vegetation may play in achieving land management requirements and land use goals.

4. *Low Priority Sites.* These sites require no further action. Vegetation is not expected to influence remedy performance, for better or for worse, and *active* vegetation management is not needed to achieve land use goals and requirements.

<u>Phase II: Problem Formulation</u>

This is perhaps the most difficult phase because it is conceptual and requires creative thinking. Ecologists will initially *conjecture* ways to improve vegetation management based largely on a conceptual understanding of the role plant ecology plays in remedy performance, risk management, and land management.

5. *Develop Conceptual Plant Ecology Models for High Priority Sites.* Conceptual models are the product of this creative phase. Using a conceptual model, ecologists will pull together existing information about high priority sites (from Phase I) and conjecture scenarios about how plant ecology can be (or can't be) managed and manipulated to produce more sustainable remedies and land management practices. Conceptual models can take the form of narrative, diagrams, and calculations.

6. *Select Assessment and Measurement End Points.* For our purposes, an end point is a characteristic of the site's ecosystem that is an indicator of the response of the system to existing or alternative vegetation management strategies or practices. *Assessment* end

points are explicit or direct indicators of the value of a vegetation management practice. For example, water flux through a disposal cell cover may be an important assessment end point for evaluating vegetation management practices on the cover (e.g., spray, let plants grow, or accelerate plant establishment). If the assessment end point can be measured directly, then assessment and measurement end points are the same. If the assessment end point cannot be measured directly, then a *measurement* end point is selected that is either quantitatively or qualitatively related to the assessment end point. For example, if it is not possible to directly measure water flux through a cover, then a water balance model might be used to estimate flux based on soil physical properties and plant canopy parameters. Assessment and measurement end points that relate a management alternative to cost and risk may also be selected.

Selection of end points requires a good conceptual ecological model—an understanding of ecological processes acting at a site and how management practices could have either beneficial or deleterious effects on those processes.

Phase III: Characterization and Analysis

Phase III moves the framework process from the conceptual to the actual. This phase consists of characterizing components, attributes, and processes of the site ecology as needed to evaluate and project current and future ecological conditions as related to remedy performance, risk, and land use. This phase basically fills in the gaps of information needed to fine-tune the conceptual model. This new information becomes the basis for (1) a second, more detailed screening or prioritization of sites and (2) explicit proposals for improving vegetation management (Phase IV).

7a. *Characterize Current Climate, Soils, and Plant Ecology.* Applicable information on existing climate, soil properties, plant communities (structure), and ecophysiological processes (function) at a site will be acquired in this step. It will likely involve both literature review and field characterization activities.

7b. *Project Climate Change, Pedogenesis, and Ecological Succession.* Development of sustainable vegetation management practices will also require projections of future ecological trajectories and conditions. This step may include a review of climate change models and characterization of reference plant communities, soils, and climate analog (reference) sites in order to identify likely future scenarios.

8a. *Evaluate Ecological Effects on Remedy Performance and Risk.* The purpose of this step is to input new site information from Steps 7a and 7b and evaluate (or re-evaluate) how the performance of remedies (and compliance strategies) may be influenced by current and future ecological conditions. This should lead to a refinement of the conceptual model—the scenarios describing how plant ecology can be (or can't be) managed and manipulated to produce more sustainable remedies.

8b. *Evaluate the Ecological Basis for Land Management Practices.* In parallel with Step 8a, this step will input new information acquired in Steps 7a and 7b to re-evaluate the ecology and practicability of current land management practices.

9. *Could Changes in Vegetation Management Potentially Reduce Risks and Costs?* This step uses the new characterization and analysis data (Steps 7 and 8) to select sites that would most likely benefit from a change in vegetation management strategies and practices. Ecological benefits and policy benefits will be considered, but the focus will be to identify sites where vegetation management will most likely lead to reductions in (or avoiding increases in) LTS&M costs and risks.

10. *No Further Action.* At these sites, changes in vegetation management would not be expected to reduce LTS&M costs or risks.

<u>Phase IV: Testing and Implementation</u>

Ideas for improving vegetation management practices will be judged by their likelihood of reducing near-term *and* long-term costs, human health risks, and ecological risks. Phase IV involves proposing specific vegetation management improvements and then either applying the best ideas directly or field-testing ideas first. Monitoring and cost/risk evaluations shall follow in an iterative manner regardless of whether ideas for improvements are implemented at a site or tested first.

11. *Propose Vegetation Management Improvements.* Knowledge of the role plant ecology plays in remedy performance, risk management, and land management practices (knowledge gained during Phases I–III) will become the basis for ideas to improve vegetation management at the high-priority sites (sites that survive the screening process: where plant ecology matters and where there is a strong likelihood that an improvement would reduce costs and risks). For example, if LTS&M currently includes annual spraying of a disposal cell at a site where ground water protection is required, and the ecological evaluation indicates that plants could create a favorable water balance in the cover, then a proposed improvement might be to simply discontinue spraying.

12a. *Apply Best Proposed Improvements.* The best ideas will either be implemented without additional information or field-tested first. The following factors should be considered when making this decision: (1) the adequacy of existing information, (2) the estimated cost and practicability of implementing the idea, and (3) the cost of conducting a field test to acquire more or better information.

12b. *Design and Conduct Field Tests.* Field tests are conducted when (1) existing information is considered to be inadequate, (2) the costs of the field test are defensible, (3) success would significantly reduce LTS&M costs and long-term risks, but (4) the consequences of failure (e.g. increased risks and costs) are unacceptable. In the example in Step 11, an alternative proposal would be to increase the water storage capacity of the soil cover and accelerate plant establishment. This type of cover *renovation* may require an initial increase in LTS&M costs but could significantly reduce long-term costs and risks if successful. Such ideas for improvement should be field-tested first.

13. *Monitor Improved Vegetation Management Practices.* Regardless of whether an idea for improvement is implemented at a site or field-tested first, monitoring is necessary to know if the improvement is working. Assessment and measurement end points (Step 6) are used

to guide the selection of monitoring parameters. For improvements that have been implemented at a site, monitoring may become part of the LTS&M inspection protocol. For field tests, monitoring data support the scientific method (accept or reject hypotheses). Step 13 can also include modeling to project the future performance of an improvement.

14a&b. *Assess Current and Future Risks and Costs.* Monitoring results (Step 13) are input to evaluations of current and future risks and costs. In an iterative manner, monitoring results and cost/risk evaluations support decisions such as (1) continue or discontinue a vegetation management practice, (2) revise a practice, (3) implement a field-tested improvement, or (4) propose and field-test new ideas.

Using this framework, we can test and employ sound science-based improvements in vegetation management practices to achieve the twin goals of reducing costs and risks both now and in the future.

References

DOE, 2004. *Managing Today's Change, Protecting Tomorrow's Future, Strategic Plan*, U.S. Department of Energy Office of Legacy Management, Washington D.C.